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OPTICAL SENSING HEAD AND METHOD FOR FABRICATING THE SAME

The invention relates to an optical sensing head, in particular for reading out an optical data memory, and a method for fabricating such a sensing head.

A conventional optical sensing head, such as is used for example in a CD player or a DVD player, is generally composed of discrete active and passive components which are produced individually and installed in a hybrid fashion in a metal housing. Such a sensing head typically comprises a laser source, optical components such as lenses and beam splitters, a deceleration plate and detectors for monitor functions and signal functions. In order to measure the tracking, spacing and signal level, the signal detector here senses the light which is emitted by the laser diode and reflected by the CD or DVD. The monitor detector is used to check the emitted laser power.

The monitor detector is generally arranged in the vicinity of the laser source. For example it is possible to provide for some of the laser beam to strike a monitor photodiode directly behind a housed laser diode. The signal detector is typically mounted as a single component on the metal housing of the sensing head.

Such a sensing head has a size of approximately 30 mm x 40 mm and is relatively large and heavy as a result of the discrete design. The monitor detector and the signal detector are located in separate housings and must be individually adjusted.

This is where the invention comes in. The invention, as characterized in the claims, is based on the object of providing an optical sensing head which has a low weight and a small spatial requirement and whose components can easily be matched to one another. The intention is also to specify a fabrication method for such an optical sensing head which permits cost-effective fabrication and mounting.

This object is achieved by means of the optical sensing head as claimed in claim 1 and the fabrication method as claimed in claim 16. Further refinements of the invention emerge from the subclaims 2 to 15 and 17 to 21.

According to the invention, an optical sensing head of the type mentioned at the beginning has a substrate with a main surface, an edge-emitting laser component which is arranged on the main surface of the substrate and whose irradiation axis is oriented essentially parallel to the first main plane, a deflection device which is arranged on the main surface of the substrate and has the purpose of deflecting the laser radiation in a direction which is essentially perpendicular to the main surface, at least one signal detector for sensing the laser radiation which is reflected by the optical data memory, and an optical element which guides the deflected laser radiation to the optical data memory and guides reflected laser radiation to the at least one signal detector, the optical element being connected to the substrate via at least one supporting element.

By integrating a plurality of functions on a single substrate (submount), it is possible to achieve a very small size, and, associated therewith, a low weight of the sensing head. This permits the sensing head according to the invention to be used in particular for mobile applications such as cameras, music

playback devices, games consoles, electronic books (eBooks), PDAs, laptops or computer peripherals. Furthermore, the integration permits cost-effective fabrication and mounting methods to be used so that the sensing head according to the invention can be fabricated more cost-effectively than conventional pickup systems.

In one preferred refinement of the optical sensing head according to the invention, there is provision for the deflection device to be embodied simultaneously as a supporting element via which the optical element is connected to the substrate.

An irradiation-direction signal detector is advantageously arranged on the main surface of the substrate on the irradiation axis of the laser component and downstream of the deflection device in the irradiation direction. The laser component, the deflection device and the irradiation-direction signal detector are thus arranged in this sequence one behind the other on a straight line.

It is also preferred if an opposite-direction signal detector is arranged on the main surface of the substrate on the irradiation axis of the laser component and in the opposite direction to the irradiation direction of the laser component, as an alternative to or in addition to the irradiation-direction signal detector.

A supporting element via which the optical element is connected to the substrate is advantageously arranged between the laser component and the opposite-direction signal detector.
In this context it is preferred if the supporting element which is arranged between the laser component and the

opposite-direction signal detector is provided with a metallic or dielectric mirrored layer on its surface facing the laser component. As a result, it is possible to effectively counteract stray light of the laser component passing into the opposite-direction signal detector.

Alternatively, the supporting element which is arranged between the laser component and the opposite-direction signal detector can be provided with an absorption layer on its surface facing the laser component. This also effectively suppresses stray light passing in.

An even more wide-ranging reduction in stray light which passes in can be achieved by virtue of the fact that the supporting element which is arranged between the laser component and the opposite-direction signal detector is embodied as a deflection device which deflects away stray light of the laser component from the opposite-direction signal detector. The supporting element advantageously deflects the stray light in a direction essentially perpendicular to the main surface.

The integration of an optical sensing head according to the invention can be increased further by virtue of the fact that the at least one signal detector is formed in the substrate. The at least one signal detector preferably comprises an array of PIN photodiodes which are formed in the substrate.

In one preferred development of the optical sensing head, a monitor detector for checking the irradiated power of the laser component is also integrated on the substrate.

In a further embodiment, the supporting elements are arranged to the side of the deflection mirror, and the detectors are

installed between the mirror and the supporting elements. The optical element is mounted on the supporting elements.

The substrate is advantageously formed by a silicon substrate. Cost-effective processes of the semiconductor industry can then be used for the fabrication and mounting method.

The at least one supporting element and/or the deflection device are expediently produced from glass and are connected nondetachably to the substrate for example by bonding or anodic bonding.

The main surface of the substrate preferably has an area of 10 mm^2 or less.

In one method according to the invention for fabricating an optical sensing head described above, during the fabrication of the deflection device
- a glass wafer is sawn into individual strips,
- surfaces are ground onto the strips at a predetermined angle, in particular an angle of approximately 45°,
- the ground surfaces are coated with a highly reflective mirrored layer in order to obtain a deflection prism for the deflection of laser beams, and
- the deflection prisms are orientated and connected nondetachably to the substrate.

The deflection prisms are advantageously connected to the substrate by anodic bonding. Before the glass wafer is sawn, regions on the front side of the glass wafer are expediently metalized in order to provide soldering surfaces for connecting optical components to the substrate after the connection of the deflection prisms. It is also preferred to

introduce trenches into the rear side of the glass wafer by sandblasting before the glass wafer is sawn.

In a particularly advantageous refinement of the method according to the invention, the supporting elements are fabricated from the glass wafer at the same time as the deflection device.

An array of PIN photodiodes is preferably formed in the substrate as signal detector/detectors.

Further advantageous refinements, features and details of the invention emerge from the dependent claims, the description of the exemplary embodiments and the drawings.

The invention will be explained below in more detail by means of exemplary embodiments in conjunction with the drawings. In each case only the elements which are essential for understanding the invention are illustrated. In said drawings,

Fig. 1 shows a schematic plan view of a silicon submount according to an exemplary embodiment of the invention before the glass prisms are mounted;

Fig. 2 shows a section through the silicon submount in Fig. 1 after the glass prisms are mounted, with laser and optical components;

Fig. 3 shows, in (a) to (c), three variants for suppressing laser stray light in a schematic view;

Fig. 4 shows a plan view of a silicon submount as in Fig. 1 according to a different exemplary embodiment of the invention;

Fig. 5 shows a section, as in Fig. 2, through the silicon submount in Fig. 4;

Fig. 6 shows a plan view of a silicon submount, as in Fig. 1, according to a further exemplary embodiment of the invention;

Fig. 7 shows a section through the silicon submount in Fig. 6 after the glass prisms have been mounted;

Fig. 8 shows a section through a silicon submount, as in Fig. 7, according to yet another exemplary embodiment of the invention;

Fig. 9 shows a plan view of a silicon submount, as in Fig. 1, according to yet another exemplary embodiment of the invention;

Fig. 10 shows a section through the silicon submount in Fig. 9 after the glass prisms have been mounted;

Fig. 11 shows, in (a) to (d), four variants of the embodiment of the signal diodes in each of the silicon submounts according to the invention; and

Fig. 12 shows, in (a) to (e), intermediate steps of the method according to the invention for fabricating the glass prisms and mounting the glass prisms on a silicon submount.

A first exemplary embodiment of the invention will now be explained in conjunction with Figs. 1 and 2. Fig. 1 shows here a plan view of a silicon submount, which is generally designated by 10, before the glass prisms are mounted, and

Fig. 2 shows the submount 10 after mounting with laser and optical components.

The silicon submount 10 contains a silicon substrate 12 with a size of approximately 1.3 mm × 4.8 mm, which has chip bonding surfaces 14 and 16, two monitor photodiodes 18 and two signal diodes 20 and 22. A heat sink 28 is mounted on the chip bonding surface 14, and an edge-emitting laser diode 30, which emits red laser radiation 32 along the irradiation axis 34 during operation, is mounted on the heat sink 28. The chip bonding surface 16 has an integrated circuit 42, for example an amplifier circuit or laser driver circuit.

Two glass prisms 36 and 38 are connected nondetachably to the substrate 12 on the glass bonding surfaces 24 and 26 by anodic bonding. The glass prisms are used, on the one hand, as supporting elements on which an optical component 40 is mounted, for example by soldering. The glass prism 36 also serves as a deflection prism by means of which the laser radiation 32 emitted parallel to the surface of the substrate 12 along the irradiation axis 34 is deflected by 90°.

The optical component 40 guides the deflected laser radiation to an optical storage medium (not illustrated itself) and guides the laser radiation reflected there back to the signal diodes 20 and 22. The signals which are modulated onto the storage medium in accordance with a dash pattern or dot pattern are used in a manner known per se for data transmission, and for tracking detection and tracking guidance, after they have been sensed by the signal diodes 20 and 22.

The glass prism 38 is mirror-coated with an aluminum layer 44 on its surface facing the laser diode 30 in order to prevent

stray radiation passing from the laser diode 30 to the signal diode 22. Instead of an aluminum layer, it is also possible to provide the glass prism with a different metallic layer, for example an AlSi layer, or with a dielectric mirror, for example made of aluminum oxide/Si.

Fig. 3 shows, in (a) to (c), three further variants for suppressing laser stray light in a simplified view. In the variant in Fig. 3(a), the glass prism 38A is provided with an absorbent layer 44A instead of with a mirror 44. In the configuration in Fig. 3(b), the glass prism 38B is embodied as a 45° mirror whose mirrored surface 44B reflects away laser stray light in the upward direction. The surface 44B can be embodied here as a standard mirror with a metallic or dielectric coating, or be provided with an absorbent coating. Fig. 3(c) shows a refinement of the configuration of Fig. 3(b) in which the 45° mirrored surface 44C of the glass prism 38C is directed in the downward direction, that is to say deflects laser stray light into the substrate where it is absorbed. Here too, the surface 44C can either be mirror-coated or provided with an absorbent layer.

Again with respect to Figs. 1 and 2, the silicon substrate 12 thus functions not only as a carrier for the glass prisms 36, 38 which are arranged on it, for the laser diode 30 and for the IC 42, but also as a heat sink and as a substrate for a PIN photodiode array which comprises the monitor photodiodes 18 and the signal diodes 20 and 22. The monitor photodiodes 18 are arranged in the vicinity of the laser diode 30 and measure the backward reflection of one of the optical components in order to regulate the laser power.

Another embodiment of a silicon submount 50 according to the invention is illustrated in Figs. 4 and 5. Here, identical

reference symbols designate the same elements as in Figs. 1 and 2. The silicon submount 50 differs from the silicon submount 10 in particular through the arrangement of the monitor photodiode 52. The monitor photodiode 52 is arranged under the deflection prism 36 in this exemplary embodiment. It takes up, as monitor signal, that part 54 of the laser radiation 32 which is let through by the mirror-coated surface of the deflection prism, and is reflected in the direction of the monitor diode 52.

Furthermore, the exemplary embodiment in Fig. 5 realizes, as means for reducing the stray light, the variant which is shown in Fig. 3(c) in which the supporting element 38C is embodied as a deflection element with a mirrored surface 44C which is inclined at an angle of 45° with respect to the substrate 12.

Figs. 6 and 7 show a further exemplary embodiment of a silicon submount 60 according to the invention. Here too, identical reference symbols designate the same elements as in the silicon submount 10 in Figs. 1 and 2. In the silicon submount 60, instead of the pair of signal detectors 20 and 22 in Fig. 1, a single signal detector 62 performs all the functions for tracking, measurement of the signal level and focusing. The monitor diode 64 is arranged here directly downstream of the first chip bonding surface 14 in the direction which is opposed to the irradiation direction of the laser.

Fig. 8 shows a refinement of the configuration in Fig. 7 in which the second supporting element 74 is bonded onto the substrate 12 in the irradiation direction, downstream of the single signal detector 62. The arrangement of the other elements corresponds to that in Fig. 7.

A further exemplary embodiment of the invention is illustrated in Figs. 9 and 10. In the case of the silicon submount 80, in addition to the glass bonding surface 82 which is used to hold the deflection prism 84, a further glass supporting point is dispensed with. The deflection prism 84 thus constitutes the single supporting element for the optical component 40. The arrangement and configuration of the signal diodes 20, 22 corresponds, in the exemplary embodiment shown, to that of Fig. 1, and the arrangement and configuration of the monitor diode 64 corresponds to that of Fig. 6.

Fig. 11 shows, in (a) to (d), four variants of the embodiment of a signal detector array 90, 92, 94 or 96. Each of these arrays permits good measurement of the tracking, spacing and signal level of the reflected laser light and can be used for one of the signal detectors 20, 22 and 62 of the silicon submounts discussed above.

The fabrication of the glass prisms and the mounting of the glass prisms on the silicon submount will now be explained with reference to Fig. 13. Here, the fabrication of the submounts is carried out in the wafer composite, for example on 150 mm or 200 mm wafers, it being possible to arrange for example 1500 submounts on a 150 mm wafer.

In a first working step, Fig. 12(a), regions 102 which will later be used as soldering surfaces for connecting the optical component 40 are metalized onto a glass wafer 100. Then, approximately 20 μm-deep trenches 104 are made on the rear side of the glass wafer 100 by sandblasting. Then, the glass wafer 100 is sawn so that a multiplicity of individual strips 106 is produced, Fig. 12(b).

Then, as shown in Fig. 12(c), surfaces 108 are ground to 45° jointly on a plurality of the strips 106. These surfaces 108 are polished in the next working step and coated with a highly reflective mirror for the deflection of laser beams. The prisms are then oriented on a silicon wafer 110 and anodically bonded, Fig. 12(d).

Through various further sawing steps, the glass center part is respectively cut out so that a deflection prism 36 and a further supporting element 38 are produced from each glass strip 106. The individual submounts 112 are also separated from one another, Fig. 12(e). Here, the submounts 112 are firstly still held on a film and then placed in the sensing head housing by means of pick&place in a manner known per se.

While the invention has been shown and described particularly with reference to preferred embodiments, it is clear for a person of skill in the art that changes in form and details can be maid without deviating from the idea and scope of the invention. Accordingly, the disclosure of the instant invention is to illustrate the scope of the invention which is presented in the subsequent claims.